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**From Seedlings to Ships:
Supply Chain Management in the Venice Arsenal, 1320-1800**

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Abstract

The Venice Arsenal was one of the earliest large industrial complexes, started in 1104 with expansions in 1320 and after 1660. It made all the warships and much of the commercial shipping used by Venice. It is reputed to have innovated producing standardized parts enabling the mass-production of galleys. Preliminary investigations show a rich data set for the period 1665-1779 revealing how the Arsenal was managed. This research provides a significant insight into one aspect of the Arsenal's activities: the management of the wood used and the forests supplying it. A historical investigation will show how its production activities were planned, organized and controlled from the Arsenal's inception until Napoleon's conquest of Venice in 1797 and its independent operations gradually ceased. We anticipate finding historic management policies and processes that were effective and compatible with modern theory and practice, and observe how those evolved over time.

146 words

Keywords: Supply Chains, Venice Arsenal, Innovation, Production Management, Forest Management.

Note for Reviewers: Although this is submitted as a developmental paper as of February, 2016 it is the authors' intention to continue working on it so that a full paper draft would be available and presented at the conference in September.

From Seedlings to Ships:

Introduction

The Venice Arsenale was one of the earliest large industrial complexes, first established in 1104. Venice was a significant naval power and trading city-state so the Arsenale was a major enterprise, making all the naval warships and much of its commercial shipping for the next 800 years, until Napoleon's invasion of Northern Italy. The Arsenale was at the forefront of production technology and management, reputed to have innovated methods for producing standardized parts enabling the mass-production of galleys. The Arsenale allegedly could produce one ship per day using a production line approach. It is unclear how these approaches were implemented or how they may have been developed or evolved throughout the Arsenale's existence. Very little is known about the management of early industrial operations and this study would provide a significant insight into those activities. This investigates a significant area in the historical development of production management practices in the case of the Arsenale that is widely known but has not been well or fully studied. The study should make a significant contribution to knowledge about operations management before the industrial revolution and outside the USA and UK.

This research specifically looks at the developing sophistication and complexity of the Venetian supply chain for wood. Venice initially relied on trees grown on its own islands but those were soon exhausted and mainland forests became important sources. Italian forests (as shown in Figure 1) at Montello and Isonzo were used first; and then, in 1537, the Croatian forests in Montona came under Venetian control. The Montona forests and their management will be the focus of this investigation since the documentation on them is more extensive, and their management was more demanding.

Insert Figure 1 about here

280 words

Research Questions

The objective is to develop an understanding of how a large factory was managed, and to observe how that evolved and developed over a long period. The archival materials would ideally show:

- 1.) Staff numbers, time worked and work assignments to provide insight into scheduling and workload management within each shop, between them and across the whole Arsenale.
- 2.) Capacity available and its use for making various items, in both tightly linked assembly and less time-critical production activities. Again, we would look at individual shops, those with which they directly interact, and for the Arsenale as a whole
- 3.) Whether items were made specifically to meet individual production requirements or made for “stock” and then provided when needs arose. A particular concern is whether materials were stockpiled in peace-time at steady rates of production for later rapid assembly when hostilities threatened or other occurred. The Arsenale made both military and commercial vessels. Most attention has focused on its work making warships yet the production of commercial shipping might also have benefited from these techniques and management practices. To what extent did the commercial ships use standardized components, and was there any standardization of them as there was for warships. Were these vessels also made on production lines or in fixed positions like the production of “Liberty Ship” freighters during World War 2 in the USA?
- 4.) Ideally, we would like to trace the Arsenale’s development, hypothesizing that it began as a number of individual shops, each working individually with little or no coordination. Later improved management would start to integrate these operations into a coordinated whole. We would consider issues: i.) Management would shift from individual shop managers or Masters to larger units and eventually a Manager for the whole operation. ii.) Product flows would change from irregular and uncoordinated shifts between individual shops to a more smooth and coordinated flow, with ships being passed between shops at a regular, steady pace. iii.) Capacity would be balanced between the shops, so that no one would limit output and resources would be evenly used. iv.) Staff and material resources would be effectively planned and managed, with wasted effort and materials brought under control and wastage reduced as management and coordination improved
- 5.) The Arsenale’s capabilities were important for managing the fleet. Ships were taken out of service whenever conflicts ended and stored. The factory’s ability to restore these ships to operations was then a critical strategic and management requirement. Re-use and refurbishment were then essential design and operating issues. It is unclear how the Arsenale integrated these activities with its new construction.

432 words

Methodology:

The research will be based primarily on an analysis of historic archival records, supported with contemporary historic commentaries and relevant modern secondary sources. Although written reports and other text documents will be used the primary focus will be on extracting numerical information about the Arsenale's operations from the accounting records that have been preserved. Content analysis will be used on the documents. The accounting data will be assessed using basic statistics or visualizations of trends or other patterns where appropriate. The research has been undertaken at the Arsenale and other Archives in Venice: the Archivio di Stato di Venezia (ASV); the Biblioteca del Museo Correr (BMC) and the Biblioteca Nazionale Marciana (BNM). Preliminary investigations show a rich data set exists for the period 1665-1779 that reveals how the Arsenale was managed. While the factory's general layout and organization supports current views of its operations no detailed analysis of its management has been undertaken, developing that detailed analysis is our objective.

In the Arsenale there were a number of different shops (and perhaps operations within each shop) arranged so that ships passed through them sequentially. The issues to be investigated are how well or closely those flows were managed: was there one central manager for the Arsenale as a whole that planned the operations of the whole, or was each shop the province of its own "master" who operated independently, or if "managed" how they coordinated their work with those of the previous shop and the requirements of later ones? In particular, can the evolution of the factory's management be identified with possible shifts from the production of single vessels, to the uncoordinated production of multiple vessels simultaneously (in "parallel") to a staged approach in which multiple vessels are sequentially made in a phased production and assembly process

In addition, we would investigate the impact that Venetian practices had on other naval powers, investigating the construction of French warships using the French National Archives in Paris or the naval archives in the *Service Historique de la Marine* at Vincennes. Notably, under Napoleon the Arsenale was closely involved with French naval developments. The primary objective of those searches would be to identify direct links with Venice and identify any influences that Venetian practices had more widely. If no direct links are found we would look for indirect ones and also a potential cross-country comparison. Thus, even if no direct links are found these peripheral investigations can be made productive.

408 words

1039 words

Conclusions

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Figure 1
Venice and its Forest Regions



Note: This was taken from Google Earth, cropped with captions added for each region.

Figure 2
Venice Arsenale Development



Note: this was taken from: <http://arsenalofvenice.weebly.com/history-of-the-arsenale.html> on 29th January, 2016.

Table 1
Timeline History of the Arsenale

Year	Event
1104	Reputedly founded by the Doge Faliero Ordelafo.
1150-1200	<i>Arsenale Vecchio</i> (Old Arsenal).constructed, then extended 1225-1304
1304-1322	Ropery constructed <i>Corderie della Tana</i> (Casa del canevolo),
1325	<i>Arsenale Nuovo</i> 's construction, Construction of workshops for the manufacture of oars, deposits of tar, cables, rigging, wood, nails, anchors and chains in the southern belt of the new dock,
1377-1440	Construction of the <i>Casa della Polvere</i> (Powder House)
1390	Construction of the <i>Fonderie</i> (Foundries).
1453	Fall of Constantinople. The Republic starts upgrading the Arsenale against the Ottoman threat.
1460	Start building up the nucleus of origin of the Sale d'Armi (Sale of Arms) and Artiglieria (Artillery) workshop in Stradal Campagna. Construction of the <i>Porta di Terra</i> (Land Gate), a monumental entrance to the Arsenale
1473	Construction of the Arsenale Nuovissimo
1476-1480	Construction of the Darsena NUovissima,
1516	Opening of the channel that connects the Darsena Nuova with the Darsena Nuovissima and of the Bucintoro channel between the Darsena Vecchia and the Darsena Nuova.
1525-1528	Completion of the <i>Novissimetta</i> .dock, with new foundries for producing iron and bronze.
1561-1564	Construction of the Artillery workshops
1566-1574	Upgrading of the Arsenale Nuovissimo: construction of covered sites at Isolotto and of <i>gagiandre</i> (1573). Construction of <i>tezon delle sieghe e dei legnami</i>
1569	Construction of the Darsena delle Galeazze. Covered sites built for a new type of ship: the <i>galeazza</i> .
1571	the Battle of Lepanto, decisive contribution of the technologically advanced Venetian fleet armed with cannons
1600-1700	Transformation of naval technology and consequent processes and the Arsenale's organization.
1667	First Northern European style ship built
1684-1745	Restructuring and roofing of the Arsenale Nuovissimo and the Novissimetta to adapt them to new style large ships
1686-1692	Enlargement of the river and Arsenale's entrance for larger ships.
1750	Construction of the Squadratori building on the Galeazzo canal,
1797	Treaty of Campoformio. French conquest and shipment of artillery and other weapons to France.
1798-1805	Austrian domination. Ships are repaired for the Austrians and shipbuilding restarts.
1806-1814	French domination. The French fleet is based at the Arsenale. A new programs to modernize the Arsenale and convert it to the French shipbuilding system.
1814-1848	Second Austrian domination.

Note: taken from: <http://arsenalofvenice.weebly.com/history-of-the-arsenale.html> on 29th January, 2016.